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WORKSHOPS OF THE SOO (2008 LE HAVRE). SYMPOSIUM: MASSIVE ROTATOR CUFF TEARS IN PATIENTS YOUNGER THAN 65 YEARS

Massive rotator cuff tears in patients younger than 65 years. What treatment options are available?

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Summary Management of massive rotator cuff tears is a therapeutic challenge in patients younger than 65 years, particularly if still working. According to our hypothesis, choice of the most appropriate treatment option mainly depends on the patient's functional status and on two predictive factors: height of the subacromial space and fatty muscle infiltration. This is a retrospective, multicenter study of a series of 296 patients younger than 65 years, including 176 males and 120 females with extensive or massive cuff tear. Patients had loss of elevation or external rotation or both in 162 cases. Four types of management of massive rotator cuff tear were performed in this study: anatomical watertight repairs, palliative treatments and partial repairs, watertight repairs using flaps or cuff prostheses and reverse shoulder prostheses. At follow-up, the Constant score (65.6 ± 3.4) and active elevation ($147.7^\circ \pm 32^\circ$) had significantly improved. Active external rotation with elbow at the side, and acromiohumeral interval (AHI) were unchanged. Work-related injuries, previous surgeries and complications were correlated with a poorer Constant score. At follow-up, the anatomical repair sub-group had a significantly better Constant score than the three other treatment groups but involved patients with unchanged AHI and a low degree of fatty infiltration of the infraspinatus muscle. The reverse shoulder prostheses sub-group showed better outcomes in terms of function benefits. The presence of a long biceps was correlated with the use of a palliative treatment. In the light of the results and literature, an approach to treatment is suggested related to the functional capacity

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of patients, the AHI and the degree of fatty infiltration of the infraspinatus and subscapularis muscles.

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Introduction

Management of massive rotator cuff tears is a therapeutic challenge notably in young patients especially if they are still working. Indications for rotator cuff repair should be investigated since patients younger than 65 years report better chances of tendon healing [1,2].

Two prognostic factors play a critical role in the choice of treatment: the height of sub-acromial space and the degree of fatty muscle infiltration [3–6].

Taking into account these elements, many available treatment options were thus suggested. Watertight repair is recommended whenever possible and appears to be the most successful technique [7]. If not possible, partial repair might be performed, as advocated by Burkhart et al. [8]. However, simple palliative management including tenotomy of the long head of the biceps [9], acromioplasty or even cuff debridement [10] can provide very satisfactory results. If a watertight rotator cuff repair is highly required, muscle transfers (deltoid muscle flap [11,12], supraspinatus transfer) or even implantation of cuff prostheses might be performed [13,14]. In salvage situations with a pseudoparalytic shoulder or persistent pain, the use of a reverse shoulder prosthesis was recommended despite the patient's age and the absence of arthritis [15,16]. Their overall results are satisfactory. Choice of the most appropriate technique among available treatment options is delicate.

According to our hypothesis, selection of the most appropriate treatment will first depend on the patient's functional status and on two prognostic factors which are height of the subacromial space and fatty muscle infiltration.

Material and methods

This is a retrospective, multicenter study conducted within the frame of the Société d'orthopédie de l'Ouest.

Inclusion criteria were:

- patients aged less than 65 years, suffering from a massive rotator cuff tear featuring the following associated or not criteria:
 - isolated supraspinatus tear with stage III retraction in the sagittal plane according to Thomazeau et al. [17] and Boileau et al. [18],
 - supraspinatus tear associated with infraspinatus or subscapularis tendon impairment or both,
 - acromiohumeral interval (AHI) lower than 7 mm,
 - tear of the supraspinatus associated with greater than stage II fatty infiltration of infraspinatus or subscapularis muscles according to Goutallier et al. [19];
- any surgical treatment with a minimum of 2-year clinical and radiographic follow-up.

Exclusion criteria were:

- a greater than or equal to stage III glenohumeral or acromiohumeral arthritis according to the Hamada classification.

Therefore, 296 patients were enrolled in the study and operated on by 11 orthopaedic surgeons specializing in shoulder surgery. The study group included 176 males and 120 females. Mean age was 56.5 ± 6 years, ranging from 34 to 65 years and showing a significant difference ($P < 0.05$) between males (55.8 ± 6 years) and females (57.5 ± 5 years). The dominant side was involved in 77% of cases. Thirty-seven percent of patients were retired. The remaining patients were active, 35% of who were heavy manual workers. Forty-five shoulder pathologies were work-related (16%) and 19 were due to work-related diseases (6%). Forty-three had already been operated on: 30 had cuff repair and 13 had palliative treatment (tenotomy or debridement).

Mean duration of symptoms was 31 months. The appearance or worsening of symptoms was secondary to minor trauma in 87 cases and to major trauma in 52 cases.

Evaluation of passive and active shoulder range of motion was conducted during physical examination, which provided a classification of patients according to their deficit in elevation and external rotation [20]. Patients were considered as having a deficit in elevation if they couldn't raise their arm actively beyond 90° and if the difference between passive and active range of motion exceeded 30° . Patients were considered as having a loss of external rotation, with elbow at side, if they could not exceed 30° and if the difference between passive and active range of motion was greater than or equal to 30° . Four functional statuses could be identified. Grade A patients (134 cases) had no loss of mobility, grade B patients (87 cases) had an isolated loss of elevation, grade C patients (26 cases) had an isolated deficit in external rotation and grade D patients (49 cases) had a deficit in both external rotation and elevation.

Function was rated according to the Constant scoring system [21]. Pain score was 4.6 ± 3.4 , daily living activities score was 7.5 ± 3.6 , mobility score was 21.7 ± 10.1 and muscular strength was 2.7 ± 3.2 . The mean overall Constant score was 36.4 ± 16 .

On standard radiography, the sub-acromial space (AHI), evaluated in neutral rotation, was 7.25 ± 3.5 mm. The supraspinatus tendon was torn in all 285 cases, the infraspinatus in 237 cases and subscapularis in 84. Two hundred and eighty-three cuff tears (95%) involved two or more tendons. On the whole series, a stage 3 or 4 fatty infiltration [19] of infraspinatus muscle was noted in 37% of cases and of subscapularis muscle in 17%.

Surgical procedures were divided in four groups:

- group I: watertight anatomical repairs: 103 cases of which 34 arthroscopies and 68 opened surgeries;
- group II: palliative treatments, mainly tenotomies of the long head of the biceps (48 cases of which 36 under

Table 1 Pre- and postoperative overall results.

	Preoperative	Postoperative	Improvement	P
Pain	4.6 ± 3.4	12.5 ± 3.4	7.8 ± 4.2	<i>P</i> < 0.01
Activity	7.6 ± 3.6	15.5 ± 4.6	7.9 ± 5.6	<i>P</i> < 0.01
Mobility	21.7 ± 10.2	31.5 ± 8.9	9.7 ± 11.6	<i>P</i> < 0.01
Strength	2.7 ± 3.3	6.1 ± 4.9	3.3 ± 4.9	<i>P</i> < 0.01
Constant	36.4 ± 16.0	65.6 ± 17.5	28.7 ± 20.5	<i>P</i> < 0.01
Active elevation	114.6° ± 43.9°	147.7° ± 32.8	27.9° ± 49.1°	<i>P</i> < 0.01
External rotation 1	26.2° ± 17.9°	27.7° ± 21.3°	1.3° ± 18.1°	NA
AHI (mm)	7.3 ± 3.5	7.2 ± 3.7		NA

External rotation 1: active rotation, with elbow at the side; AHI: acromio-humeral interval.

arthroscopy) and partial repairs (41 cases of which three under arthroscopy);

- group III: watertight repairs with use of a flap or cuff prosthesis: 55 cases, all treated with opened surgery, divided among 16 supraspinatus medializations, 22 deltoid muscle flaps, two mixed flaps (quadriceptal tendon) and 15 cuff prostheses;
- group IV: reverse shoulder prostheses: 49 cases.

The outcome was assessed at a minimum two-year follow-up and a mean follow-up of 67 ± 42 months. Clinical evaluation was based on mobility scores according to Constant and radiographic assessment was standard to evaluate the AHI.

Results

Early complications were observed in 16 subjects and included 12 adhesive capsulitis and four infections requiring reoperation, two of which associated with iterative rupture. Late complications included two infections. Capsulitis were found in seven watertight anatomical repairs, four flaps and cuff prostheses and one partial repair. A single one was noted following arthroscopy. Infections involved two watertight repairs, one partial repair, one cuff prosthesis and two reverse prostheses.

At follow-up, the Constant score was 65.6 ± 3.4, that is a mean improvement of 28.6 points which is highly significant (*P* < 0.01) when compared with preoperative status. Similarly, each item (pain, daily activity, mobility and

strength) was significantly improved (Table 1). Active elevation was 147.7° ± 32°, that is a mean improvement of 28° (*P* < 0.01). Active external rotation, with elbow at side, was unchanged at 27.6 ± 21.3°. Preoperative AHI was unchanged at 7.2 ± 3.7 mm. Three parameters were significantly correlated (*P* < 0.05) with a poor Constant score at follow-up: Work-related disease (Constant score: 55.7 ± 18.7 versus 68.2 ± 14.4) which was not the case for work-related injuries (65 ± 21.6); previous surgeries (Constant score: 56 ± 23.4 versus 67 ± 15.8); complication appearance (Constant score: 58.3 ± 23 versus 68.7 ± 16.3).

Findings according to the type of treatment were the followings: only group IV reported a significantly lower preoperative Constant score (23 ± 10.6) than in other groups (Table 2). At follow-up, the Constant score was significantly higher in group I (70.3 ± 15) than in the three other groups. On the other hand, improvement was better in group IV (36 ± 21.2).

According to radiographic findings (Table 2), the sub-acromial space was higher in group I (9.4 ± 3 mm) and lower in group IV (4.5 ± 3.7 mm). Similarly, 87.7% of patients from group I and 74% of those from group III had a fatty infiltration of infraspinatus less than or equal to 2 whereas 67% of patients from group IV and 54% of patients from group II had a fatty infiltration of infraspinatus greater than 2. Within group III, no significant difference was found between Constant scores according to the type of treatment even if supraspinatus medializations and cuff prostheses reported better results than deltoid muscle flap technique.

Results are classified in Table 3, according to the functional status of patients. Patients showing no shoulder deficit

Table 2 Features of each group.

	Group I	Group II	Group III	Group IV
Age (years)	55.2 ± 6.2	57.1 ± 5.5	56 ± 5.4	58.8* ± 4.6
Follow-up (months)	50.1 ± 27	74.4 ± 36.6*	91 ± 62*	61.4 ± 35.8
Pre op Constant	37.7 ± 17.1	40.6 ± 13.3	40.2 ± 15.9	23* ± 10.6
Post op Constant	70 ± 15.2*	64 ± 16.6	64.6 ± 15.5	59.7 ± 23
Improvement	31.6 ± 20	23.4 ± 17.9	24 ± 22.4	35.9 ± 21.3*
FI infraspinatus > 2 (%)	12.2	54.3	26	67
FI subscapularis > 2 (%)	4*	16.3	9	47.7
AHI	9.4 mm ± 2.7*	5 mm ± 3.6	6.4 ± 3°	4.5 ± 3.7°

Group I: watertight anatomical repairs; group II: palliative treatments or partial repairs; group III: flaps or cuff prostheses; group IV: reverse shoulder prostheses FI: fatty infiltration; AHI: acromio-humeral interval. **P* < 0.05.

Table 3 Clinical and radiographic features of non-deficitary patients.

Patients with no shoulder deficit	Group I	Group II	Group III	Group IV
Percentage (%)	39.5	38.8	19.4	2.3
AHI (mm)	9.4 ± 2.7*	6.2 ± 2.6	6.4 ± 2	2.3 ± 2.5
FI infraspinatus > 2 (%)	12.7*	63	33	67
No LB (%)	11	3.8	27	33
Post op Constant	71.8 ± 15.6*	65.4 ± 18	64.3 ± 18	61.3 ± 29
Improvement	23.2 ± 15.8	16.8 ± 13.4	12.2 ± 19.3	17 ± 25

Group I: watertight anatomical repairs; group II: palliative treatments or partial repairs; group III: flaps or cuff prostheses; group IV: reverse shoulder prostheses FI: fatty infiltration; AHI: acromio-humeral interval; LB: long head of the biceps; * $P < 0.05$.

(134 cases), had a mean duration of symptoms of 39 months. In these patients, preoperative AHI was significantly larger in group I (9.4 ± 2.8 mm) than in the other groups. Similarly, the less than or equal to grade II fatty infiltration of infraspinatus was significantly higher in group I (87%) than in the other groups. In the light of such findings, the Constant score and its degree of improvement were significantly better in group I.

Patients with loss of elevation (87 cases) had a rather short mean duration of symptoms (19 months) associated with a common trauma history in 71% of cases. Preoperative AHI was significantly larger in patients from group I (9.4 ± 3 mm) or group III (9 ± 0.6 mm) than in the other groups (Table 4). The less than or equal to grade II fatty infiltration of infraspinatus was significantly lower in patients from group IV (41%) than in the other groups. However, neither the Constant score nor its degree of improvement did significantly differ according to treatment. Only patients with preserved long head of the biceps could be included in group II, which was not the case for the remaining patients.

Only a small number of patients with loss of external rotation (26 cases) was included in each group, therefore no statistical significant correlations could be established. Treatments were mainly applied in group II (Table 5). Patients had a mean 40 months duration of symptoms, rarely associated with trauma history.

Patients with loss of elevation and external rotation (49 cases) had a rather short mean duration of symptoms (26 months). Preoperative AHI in these patients was significantly larger in group I (9.2 ± 2.5 mm) than in other groups (Table 6). The less than or equal to grade II fatty infiltration of infraspinatus was significantly lower in patients from group IV (20%) than in other groups. In the light of these findings, the Constant score and improvement in this score

were markedly higher in group I. Group II mostly involved patients with preserved long head of the biceps.

Advanced injury to the subscapularis was more uncommon. Fatty infiltration of the subscapularis muscle greater than 2 (26 cases) was managed with a reverse shoulder prosthesis in 21 cases and a palliative treatment in nine cases.

Discussion

Surgical management of patients younger than 65 years and sustaining a massive rotator cuff tear resulted in a significant improvement of patients, whatever the treatment. Anatomical repairs (group I) provided better results than other treatments, without knowing if these repairs are still watertight at the time of follow-up. Moreover, anatomical repairs were suggested to patients with better prognostic indicators, a larger AHI and a lower rate of advanced fatty infiltration than in other treatments. Reverse prostheses (group IV) were suggested to much initially handicapped patients with less favourable prognostic factors. Patients who received a reverse prosthesis showed a higher improvement of their Constant score. Palliative management and partial repairs (group II) were performed in patients with poor prognostic factors, on average older with a preserved long head of the biceps and eligible for tenotomy. Management of cuff tear with flap or cuff prosthesis (group III) was addressed to the same profile of patient than for anatomical repairs but suffering from a larger rupture and with poorer prognostic indicators. It did not provide better results than other treatment options but had a longer follow-up. Previous surgeries, work-related diseases and postoperative complications seem to be bad prognostic factors as in most series [22].

Table 4 Clinical and radiographic features of patients with loss of elevation.

Loss of elevation	Group I	Group II	Group III	Group IV
Percentage (%)	34.5	9.1	20.7	35.7
AHI (mm)	9.4 ± 3*	7.3 ± 3.2	9 ± 2.4*	4.5 ± 4
FI infraspinatus > 2	3.8*	0	6.2	58.6
No LB	13.3	0*	11	66.6
Post op Constant	69 ± 13.5	62.4 ± 20.2	66.8 ± 12.3	64.3 ± 21
Improvement	41.5 ± 19.7	34.8 ± 22.2	41.1 ± 16.8	42.5 ± 18

Group I: watertight anatomical repairs; group II: palliative treatments or partial repairs; group III: flaps or cuff prostheses; group IV: reverse shoulder prostheses FI: fatty infiltration; AHI: acromio-humeral interval; LB: long head of the biceps; * $P < 0.05$.

Table 5 Clinical and radiographic features of patients with loss of external rotation (ER).

Loss of ER	Group I	Group II	Group III	Group IV
Percentage	19.2	46.2	23.1	11.5
AHI (mm)	11 ± 4.3*	4.5 ± 1.8	7.6 ± 2.6	4.3 ± 1.5
FI infraspinatus > 2	33.3	63.6	25	100
No LB	33.3	33.3	0	33.3
Post op Constant	69 ± 7	64.6 ± 15.4	60.5 ± 14.4	70.3 ± 11.6
Improvement	28.6 ± 15.7	28.5 ± 16.4	23.4 ± 19.1	39 ± 12.1*

Group I: watertight anatomical repairs; group II: palliative treatments or partial repairs; group III: flaps or cuff prostheses; group IV: reverse shoulder prostheses; FI: fatty infiltration; AHI: acromio-humeral interval; LB: long head of the biceps; * $P < 0.05$.

Table 6 Clinical and radiographic features of patients with loss of external rotation (ER) and elevation.

Loss of elevation and ER	Group I	Group II	Group III	Group IV
Percentage (%)	30.6	34.7	10.2	24.5
AHI (mm)	9.2 ± 2.6*	6.2 ± 3	7.6 ± 4.8	5.2 ± 3.9
FI infraspinatus > 2 (%)	21.4	50	60	80
No LB (%)	0	11.7	20	41.6
Post op Constant	67.8 ± 18*	59.8 ± 21.2	62.8 ± 16.7	43.3 ± 23.9
Improvement	45.7 ± 19.5	33.5 ± 21.2	34 ± 21.1	23.5 ± 23.5

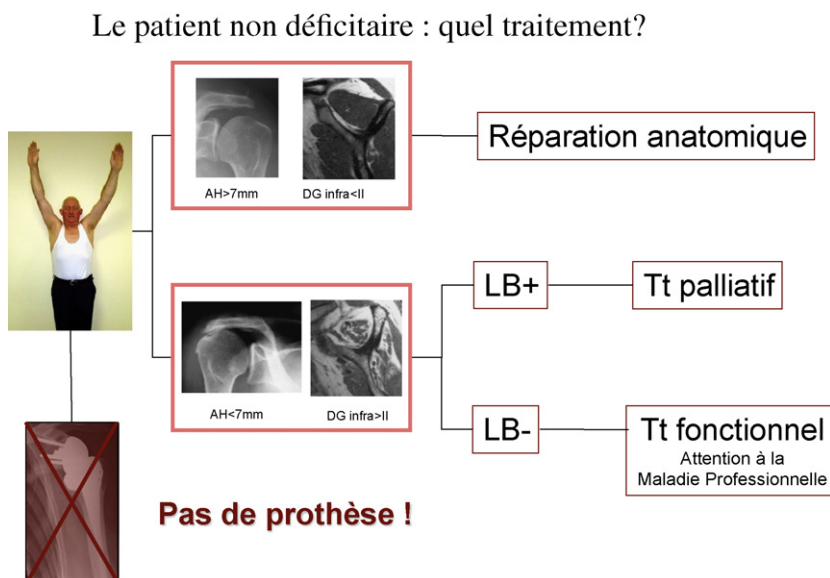
Group I: watertight anatomical repairs; group II: palliative treatments or partial repairs; group III: flaps or cuff prostheses; group IV: reverse shoulder prostheses; FI: fatty infiltration; AHI: acromio-humeral interval; LB: long head of the biceps; * $P < 0.05$.

Most treatments provided a significant improvement in active elevation in patients with preoperative deficit but no treatment could provide improvement in active external rotation when initially deficitary.

This study has many aspects. This is a multicenter and retrospective non-randomized study. However, all participating surgeons were highly skilled in shoulder surgery and indications were retained according to their personal experience, on the one hand, and available data from the literature, on the other hand, which is valuable. Moreover, the population of patients was selected according to accurate inclusion criteria. Considerations on patients' functional sta-

tus associated with radiographic prognostic factors are new. Finally, this study was the consequence of a prospective study conducted at the same time, which involved a similar population of patients enrolled according to the same inclusion criteria thus allowing comparisons. Therefore, we believe that in the daily practice, therapeutic evaluation in patients younger than 65 years with large or massive cuff rupture might be conducted the following way.

Clinical evaluation should provide an accurate classification of the patient according to his loss of shoulder active range of motion: no deficit, loss of active elevation, loss of external rotation, deficit in both mobilities [20].

**Figure 1** Management of patient with preserved shoulder active range of motion.

Le patient déficitaire pour l'élévation

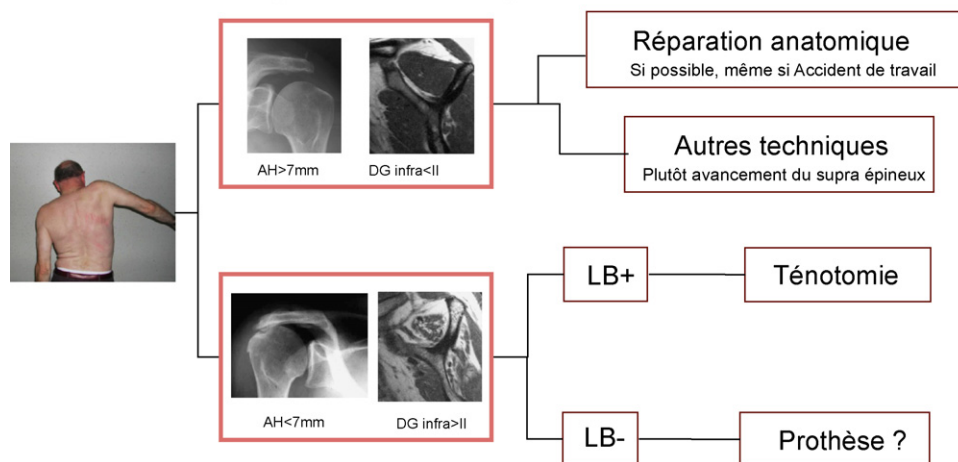


Figure 2 Management of patient with loss of shoulder elevation.

Le patient déficitaire pour la rotation externe (RE)

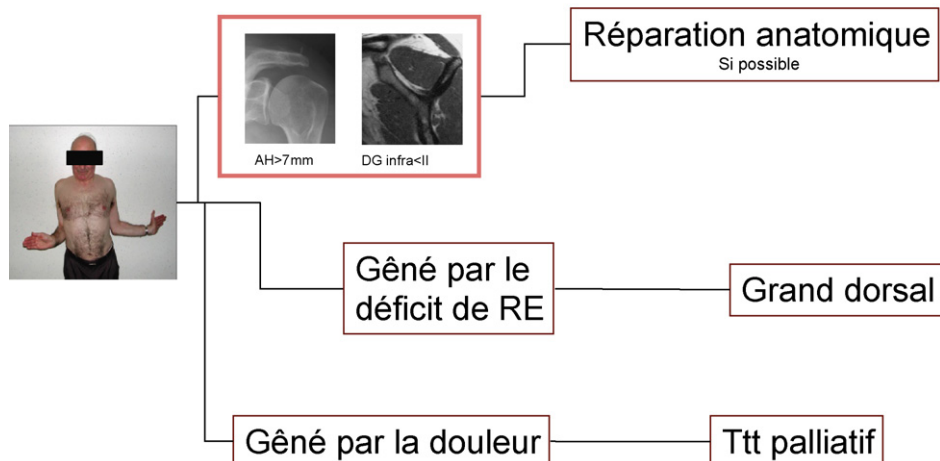


Figure 3 Management of patient with loss of shoulder external rotation.

Le patient déficitaire pour élévation et rotation externe (RE)

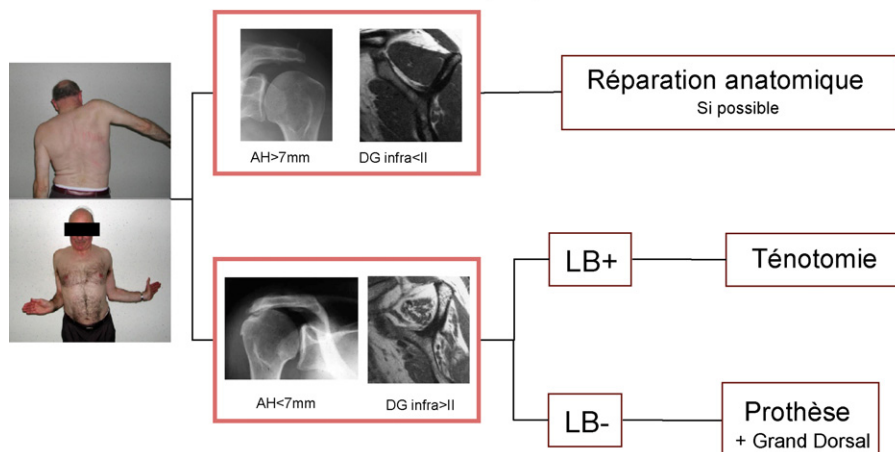


Figure 4 Management of patient with loss of shoulder elevation and external rotation.

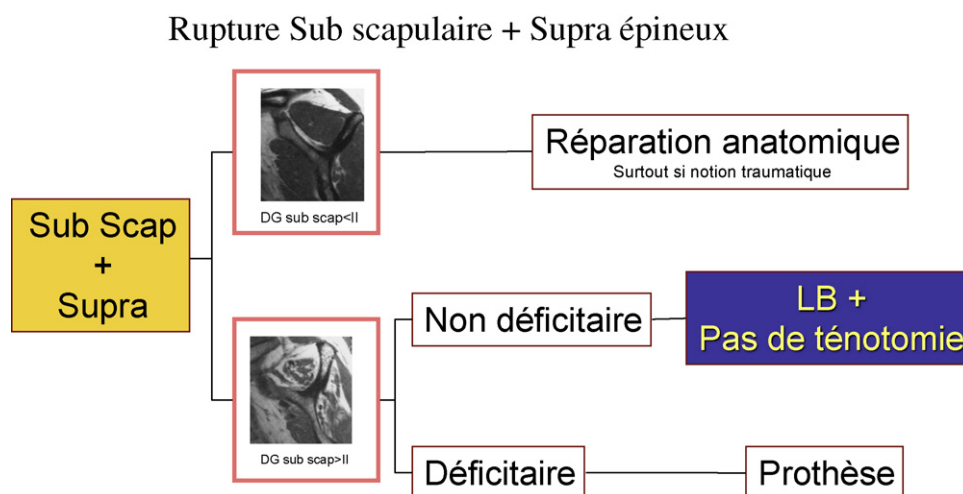


Figure 5 Management of patient with supraspinatus and subscapularis tendon tears.

When no loss of shoulder mobility is reported (Fig. 1), both prognostic indicators – AHI [3,4] and fatty infiltration of infraspinatus [5,6] and subscapularis – should be analysed on radiographs. If AHI is greater than 7 mm and fatty muscle infiltration less than or equal to 2, an anatomic repair might be performed, preferably under arthroscopy which reduces complications (capsulitis and infection). In case of narrow AHI and fatty muscle infiltration greater than 2, anatomical repair should not be attempted. There is a high risk of iterative rupture [1,23]. Therefore, a palliative treatment with tenotomy of the long head of the biceps associated or not with partial repair, or functional treatment should be performed. In any case, we believe the reverse prosthesis is contraindicated when there is no loss of active mobility, particularly in young active patients, which corroborates the conclusions drawn from the SOFCOT symposium on reverse prostheses [24]. The presence of a work-related disease should be taken into account in the therapeutic decision since it is a poor prognosis factor.

When the patient has a loss of active elevation (Fig. 2), the duration of symptoms is rather short and trauma history is frequent. If AHI is greater than 7 mm and fatty muscle infiltration less than or equal to 2, an anatomic repair might be considered by means of flap techniques preferably with supraspinatus medialization, when anatomical repair is not advisable. Deltoid muscle flaps progressively deteriorate [12] while cuff prostheses induce complications [14]. In case of narrow AHI and fatty muscle infiltration greater than 2, anatomical repair should not be attempted. There is a high risk of iterative rupture. Therefore, either a palliative treatment with tenotomy of the long head of the biceps, associated or not with partial repair, or implantation of a reverse prosthesis in the absence of the long head of the biceps could be considered. Trauma when secondary to a work-related accident does not represent a pejorative element in our study.

The rate of surgically treated patients with loss of external rotation (Fig. 3) is low (8.7%) compared with other categories whereas this rate is higher in the routine recruitment as demonstrated in our prospective study (25%). These patients are thus barely operated on. This is due to three factors: no surgical option would be able to restore active

external rotation as shown in our study apart from latissimus dorsi muscle flaps which were not included in the series because of a too small sample available. This class of patients reports the best preoperative Constant score particularly for pain item and these subjects are thus advised to carry on with their medical treatment. The worst prognostic factors are seen in this category with a high rate of AHI narrowing and advanced fatty muscle infiltration. Patients feeling discomfort with loss of external rotation might be managed with a latissimus dorsi muscle flap as advocated by Gerber et al. [25] or Warner and Parsons [26]. If pain persists despite medical treatment, a palliative option should be suggested including tenotomy of the long head of the biceps if present [10].

If the patient has a deficit in active elevation and external rotation (Fig. 4), only active elevation could be improved, as external rotation cannot be completely restored. However, implantation of a reverse prosthesis should be combined with a latissimus dorsi muscle flap as described by Boileau et al. [27].

Finally, when damage to the subscapularis muscle (Fig. 5) is associated with fatty muscle infiltration less than or equal to 2, particularly when loss of shoulder elevation is observed, we believe the reverse prosthesis is the only successful treatment option. As far as we know, muscular flaps are not reliable enough to make up for the stabilizing function of the subscapularis muscle during elevation.

To conclude, in patients younger than 65 years with large of massive rotator cuff tears, symptomatic despite medical or functional treatment, a thorough clinical analysis of patient correlated with both prognostic factors – AHI and fatty muscle infiltration – and with the presence or not of the long head of the biceps would help in the choice of the most appropriate surgical option according to the findings and should result in significant improvement in patient's functional status.

Conflict of interests

None.

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